THREE STRATEGIES FOR IMPROVING THE GRADUATION OF ENGINEERING MINORITIES

Walter W. Fisher, Peter Golding, Stella A. Quinones, Roberto Osegueda, and Barry Benedict

The University of Texas at El Paso

The University of Texas at El Paso [UTEP] College of Engineering serves a unique geo-political location on the U.S. Mexico border and works in the El Paso community to support the growing demand for high quality engineering and computer science programs that support sustainable economic growth in the region. Founded in 1914 as the Texas State School of Mines and Metallurgy, UTEP is the second oldest component of The University of Texas System. The College currently has six undergraduate degree programs including Computer Science, Civil Engineering, Electrical & Computer Engineering, Industrial Engineering, Mechanical Engineering, and Metallurgical & Materials Engineering, as well as several interdisciplinary programs.

UTEP's student population is a mirror image of El Paso's population. In Fall 2004, 71 % of a record enrollment of 18,500 students was Hispanic (citizens and permanent residents), compared to approximately 35 % less than 20 years ago which illustrates the dramatic demographic changes that have occurred in this region over the last three decades. Undergraduate engineering enrollments, which are currently about 2,100, have been rising steadily with an overall 40 % increase since 1996. Of these, 68 % is Hispanic and combined African American, Asian American and Native American populations represent an additional 3 % of the College's students. Women account for 22 % of the total enrollment.

Problem Definition

The enrollment data presented in Figure 1 shows a 40 % increase in undergraduate enrollments over the period 1996 to 2003. The decline in Pre-Engineering enrollment after 2001 is due to moving students from Pre-Engineering to an engineering major more quickly as a result of an entering students program initiated in 1998[1, 2]. Over one third of first-time Pre-engineering students are transfer students who come predominantly from El Paso Community College [EPCC]. UTEP is cooperating with EPCC to enhance the smooth transfer of student credits

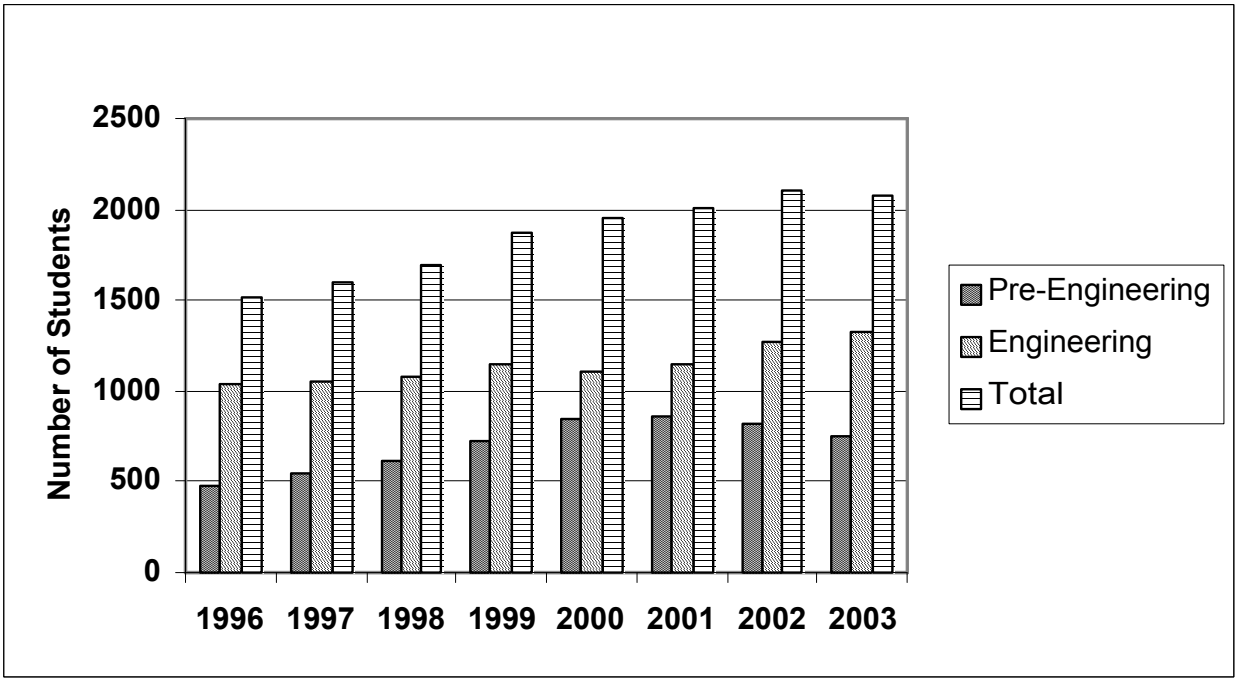

Figure 1. Engineering enrollments from 1996 to 2003.

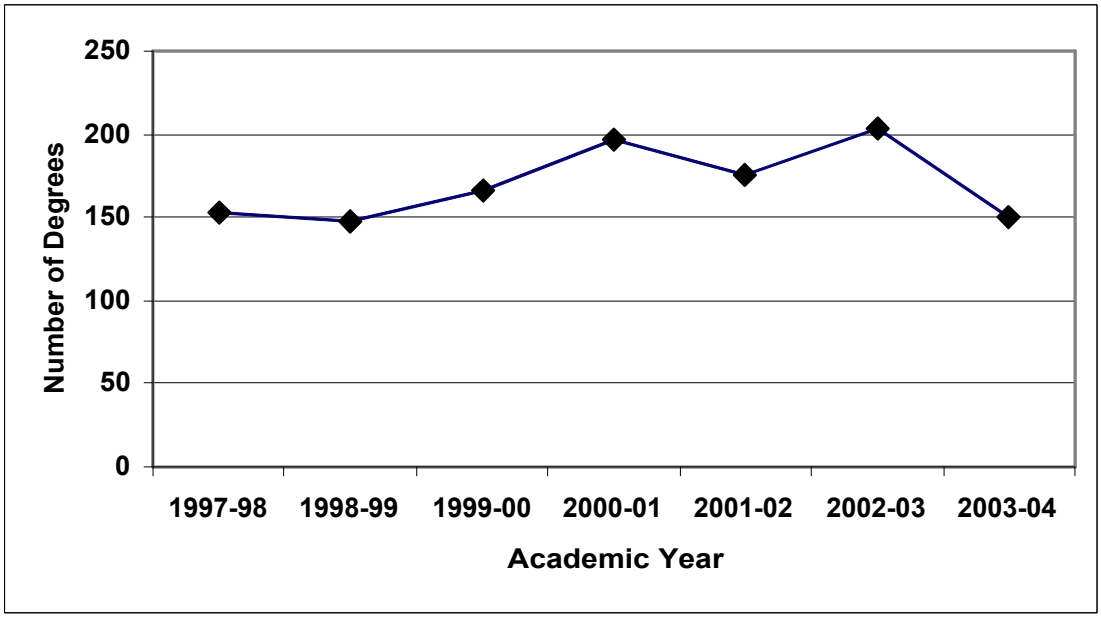

Figure 2. Engineering B.S. degrees awarded from 1997 to 2004.

between the two institutions. Although undergraduate engineering enrollment continues to increase, as shall be shown next, the yearly number of engineering and computer science graduates is essentially constant.

Figure 2 shows that the yearly number of engineering and computer science B.S. graduates has remained relatively constant over the period 1997 to 2004 with an average of about 170 graduates per year. Even though undergraduate enrollment has increased about 40 % over the same time period, a corresponding increase in number of graduates has not occurred.

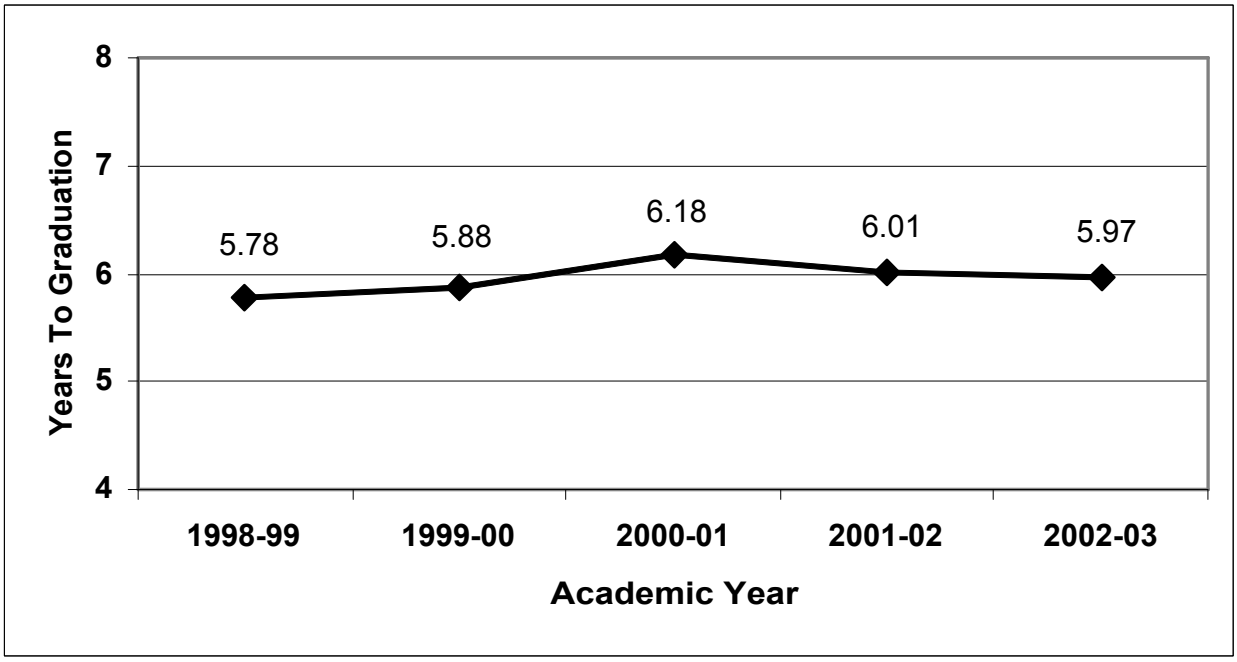

Figure 3. Years to graduation for engineering and computer science students at UTEP.

In addition to the disconnect between enrollment and yearly number of graduates, the average time to graduation for UTEP engineering students has increased to about six years as shown in Figure 3. Two academic factors contributing to the increase are poor high school preparation, especially in math, and bottlenecks caused by engineering "gatekeeper" courses[3].

Recognition that the 40 % increase in undergraduate enrollment has not led to a similar increase in B.S. graduates and that the average time to graduation has risen to 6 years has led the College of Engineering at UTEP to set new objectives for undergraduate programs. The two most critical objectives are to increase retention of undergraduate students to graduation and to decrease the time to graduation. The project described in this paper is focused on these two objectives.

The CircLES Program

In 1995 the National Science Foundation funded UTEP and five other minority-serving institutions as Model Institutions for Excellence in an effort to develop models for undergraduate science, technology, engineering, and mathematics (STEM) education that would increase the persistence, graduation and success of all undergraduate STEM students. A major component of UTEP's model is an entering students program for science and engineering students known as Circles of Learning for Entering Students or CircLES.[1, 2] Participation in the program has been mandatory for all first-time science and engineering students, including transfer students, since Fall 1998. CircLES starts with a mandatory weeklong summer orientation that includes placement testing, math workshops, university orientation, a hands-on project, and registration. Students are placed into learning communities or "clusters" of courses based on their math and English placement. Each learning community consists of a math course, an English course and the required freshman seminar, Seminar in Critical Inquiry. Students who place into developmental math continue in a learning community for a second semester. CircLES also provides students with discipline-specific advising and counseling each semester. Students remain in the CircLES program as Pre-Engineering or Pre-Science students until they enroll in Calculus I, at which time they are allowed to change into an Engineering or Science major. The CircLES program has been responsible for increasing first year retention from 67% to 80% and first semester gpa from 2.0 to 2.8

The Basic Engineering Program

One of the major objectives of the College of Engineering at the undergraduate level has been to affect long-term improvement within the Lower Division of the engineering program. The Civil Engineering (CE), Industrial Engineering (IE), Mechanical Engineering (ME) and Metallurgical & Materials Engineering (MME) programs met throughout 1999 to discuss ways of reorganizing their Lower Division programs. The final result of the process, which was implemented in the Fall of 2000, is a common Lower Division curriculum for undergraduate students in these programs. In the common Lower Division curriculum, CE, IE, ME and MME students take a common basic engineering core of eight courses: ENGR 1401 – Introduction to Engineering, BE 1205 - Graphic Fundamentals, BE 2434 - Mechanics I, BE 2326 - Engineering Economy, BE 2338 – Mechanics II, BE 2375 – Introduction to Thermo-Fluid Science, BE 2377 – Electric Circuits & Motors, and BE 2303 – Introduction to Materials Science and Engineering. Total credit hours for B.S. degrees in the four programs decreased an average of 13 credit hours (approximately one semester) as a result of this initiative. The Basic Engineering (BE) Core degree plan is listed in Table 1. After completing the two-year core program, a student is eligible to begin the Upper Division program in his or her chosen discipline

Successful on-time graduation from the common core, BE courses, is recognized as a key component for student progress and success in the Upper Division undergraduate programs. Thus, the "sticking point" for minorities and women, who are the major constituents and the

focus of retention efforts in engineering at UTEP, is the common core course work in Basic Engineering[5].

TABLE 1. Basic Engineering Core Degree Plan

First Semester		
ENGR 1401	Introduction to Engineering & Design.	4
ENGL 1311	Expository English Composition …….	3
MATH 1411	Calculus I ……	4
UNIV 1301	Seminar in Critical Inquiry ……	3
Science elective	.....……	4
		18 hrs
Second Semester		
BE 1205	Graphic Fundamentals ……..	2
ENGL 1312	Research and Critical Writing ……..	3
MATH 1312	Calculus II ……	3
HIST 1301	History of U.S. to 1865 ……	3
Science elective	.....……	4
		15 hrs
Third Semester		
BE 2434	Mechanics I (Statics & Mech. of Mat.) ……	4
BE 2326	Engineering Economy .....….....	3
MATH 2313	Calculus III .....……	3
Science elective	.....	4
POLS 2310	Introduction to Politics ……...…...	3
		17 hrs
Fourth Semester		
BE 2338	Mechanics II (Dynamics) …….	3
BE 2375	Introduction to Thermo-Fluid Science ……	3
BE 2377	Electric Circuits & Motors ..……	3
BE 2303	Intro to Materials Science & Engineering .	3
MATH 2326	Differential Equations ..... …….	3
		15 hrs

Project Focus and Strategies

The project focuses upon three strategies to enhance the successful academic path of minorities and women:

- Strategy I: Implementing Pre and Post Basic Engineering Science & Technology Assessment Testing. This establishes core competency skills by evaluation and allows focused intervention to support student competency training *en route* to progressing into the Upper Division of degree programs utilizing Basic Engineering.
- Strategy II: Leading an Active Learning Mentoring Practicum For Female Engineering Students. This involves Proactive Learning Experiences, a Professional Women in Engineering Senior Seminar, and active participation in professional societies.
- Strategy III: Improving the Support of Teaching By Students for Students In a Critical Gateway Course, Thermo-Fluids Engineering [BE 2375].

This triad of initiatives combines to provide a solid basis for achieving improvements in graduation success[6].

Implementation and Testing

In the first phase of the project, students beginning the BE course sequence and students completing the sequence are being tested via "gateway exams". These assessments will provide an indication of critical background knowledge deficiencies prior to the sequence and identifiable subject matter that is not being assimilated by students during the sequence. The data can be used by faculty and Peer Master Teachers [PMTs] to provide the foundation necessary to succeed in the BE curriculum and an indication of where improvements are needed in the subject matter and in the presentation of subject matter. The assessment also identifies students that may need assistance in the transition to the Upper Division. These students are being offered a series of tutoring workshops, led by peer master teachers. These mentors are chosen for their ability to impart knowledge and engage students.

Basic Engineering Testing

The "gateway" exams are being used to monitor student skills before and after completion of the BE Curriculum. It is critical to optimize performance in the BE program in order to improve student academic experiences in the Upper Division sequence. An improvement in the understanding of key concepts will result in a solid foundation that will ultimately lead to higher performance standards at all levels, including but not limited to the Fundamentals of Engineering Exam.

The Background Knowledge Exam (BKE) is designed to determine the math and problem solving abilities of students as they enroll for Introduction to Engineering which is the first course in the BE sequence. About 10% of the students in the course are first semester freshmen that placed directly into Calculus I. The other 90% are students that initially placed into a developmental math course or Pre-Calculus and have progressed up to Calculus I. Students in this group may have been in the Pre-Engineering program for as many as four semesters. This assessment will indicate deficiencies in critical background knowledge that will be used to adjust the content of Pre-Engineering courses and the Introduction to Engineering course. The information gained from the BKE will also be used by faculty and peer master teachers to focus on identified deficiencies. In addition, the exam will provide early feedback to students on their likely future success in engineering.

The Basic Engineering Competency exam (BEC) is designed to assess fundamental knowledge gained in the Lower Division math, science, and Basic Engineering courses. The goal is to insure that all students exiting the BE sequence of courses and entering the Upper Division programs in Civil, Industrial, Mechanical, and Metallurgical and Materials Engineering possess a minimum level of ability in fundamental areas considered essential for success in these engineering programs. Information gained from the BEC will be used to suggest adjustments in critical BE courses and will assist the overall process of total quality improvement within the BE program. Faculty and peer master teachers will focus tutoring and workshops on areas of weaknesses identified by the BEC.

The tests are now being administered at least once each long semester. The topics of the competency tests can be scored separately, as well as collectively, and this results in immediate feedback that may be utilized by Pre-Engineering and Basic Engineering administrators. UTEP students will, in general, be expected to take the test near the end of their sophomore year. This corresponds to the time when they are due to register for Upper Division courses in those programs participating in the Basic Engineering curriculum.

We hope that providing student access to information and test assessment data will enhance their engagement and ultimately their success in engineering. We are using a DotNetNuke (DNN) portal platform to provide students with information on course assignments and peer mentoring information. We also use the portal to present the cumulative data from our BEC exam process. DotNetNuke[a] is built on a Microsoft ASP.NET (VB.NET) platform. An example of the main menu from the Basic Engineering site is shown in figure 4. Figure 5 illustrates a set of cumulative data for the Dynamics course.

[a] DotNetNuke is a trademarked name, and a brand widely recognized and respected in the open source community. With over 125,000 registered users and a talented team of developers, DotNetNuke continues to evolve its software through participation, real world trial, and end-user feedback.

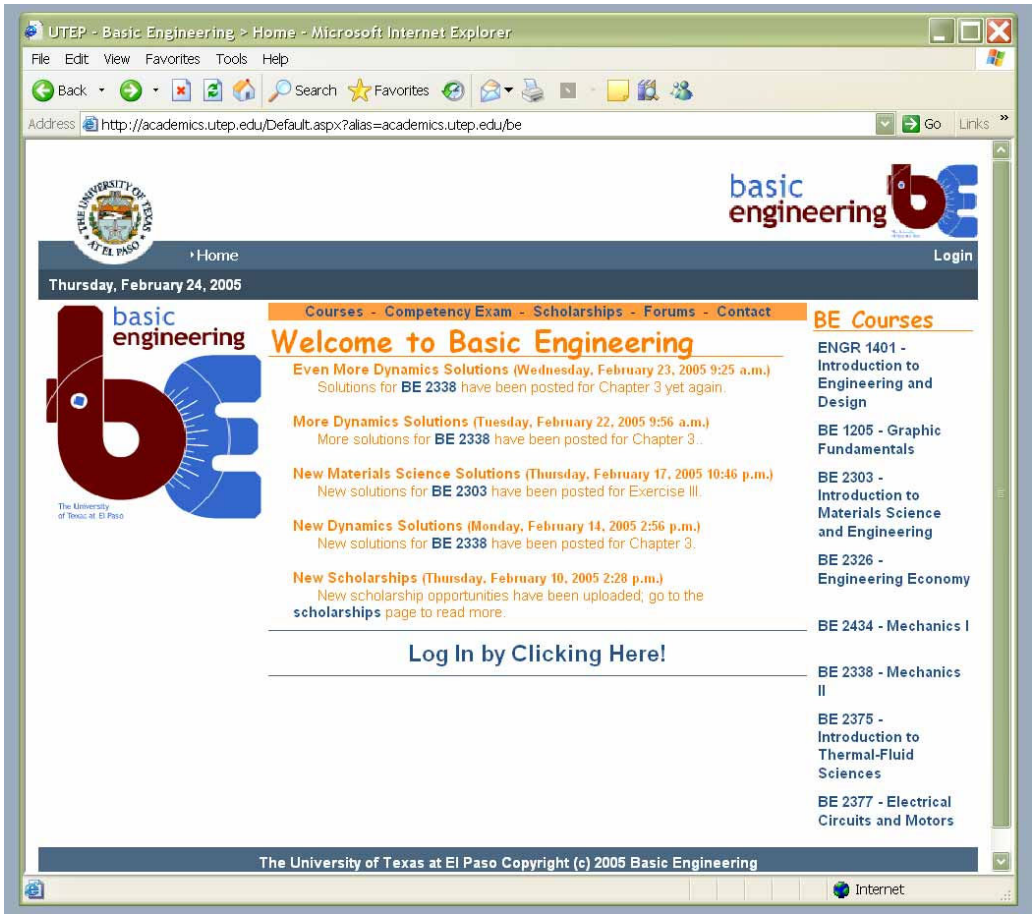

Figure 4. The DNN-based web portal used to provide Basic Engineering students at UTEP with an advanced menu of support materials and information resources. See http://academics.utep.edu/be for the latest version.

DotNetNuke is an ideal tool for creating and deploying a variety of content management systems, such as commercial web sites, corporate intranets and extranets, and online publishing portals.The software application is used by UTEP for information technology (IT) services to simplify access to various computer information services, and helps increase everyday organizational efficiency, with added capabilities including a two-tiered presentation model (skinning), multiple database support, and run-time extensibility.

In addition to providing course information, we are using the DNN portal for interface forums used for exchanging information on courses. We first developed this for use in UTEP core classes[7]. The DNN forum bulletin boards help students to learn from other students. The peer mentors moderate the dialogue for each course. This approach, coupled with the peer mentoring

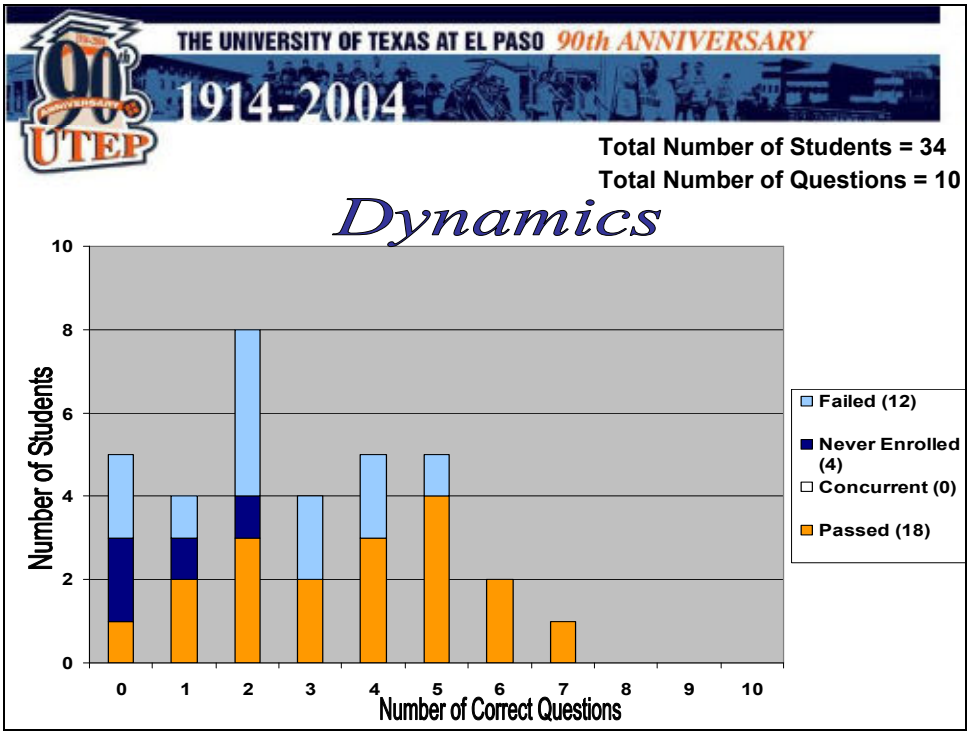

Figure 5. An example of BEC data assessment showing accumulated data for 34 students who attempted 10 questions in the dynamics section of the BEC exam in October 2004, showing the results achieved by students related to their Dynamics course experience. See http://academics.utep.edu/be for the latest data.

in courses, and the information technology services we are providing may enhance the student learning experience substantively.

Peer Mentoring in Critical Gateway Courses

Of the eight course Basic Engineering sequence, there are three courses that have received notoriety as 'gate-keeper' courses. These courses are Mechanics I (statics and mechanics of materials), Mechanics II (dynamics) and a combination thermodynamics and fluids course, known at "Thermo-Fluid Science." The Thermo-Fluid Science course has been targeted for intervention using peer mentors.

This course requires students to solve problems using methodologies that are well recognized, but in order to achieve a command of the subject requires much practice. Since the course integrates the material originally covered in two courses, MECH 2375 *Thermodynamics* and

MECH 4354 *Fluid Mechanics*, the opportunity for practice is not always achieved in the classroom. We are instituting the use of Peer Master Teachers [PMTs], who will provide the equivalency of tutorials to the students enrolled in the course. These tutorials involve study sessions led by the top students from previous sections of this course in what is effectively peer-to-peer instruction. The PMT students will receive training in teaching strategies and methods and the role of actively engaging peers. The process, training and methods used will be documented and will form the basis for dissemination to other courses, including but not limited to the Mechanics I and Mechanics II courses mentioned above. The project is seen as a catalyst for change whereby "gate-keeper" courses become new "gate-ways" to success. It is planned to incorporate a variety of pedagogical approaches – strategies and approaches that have proven successful in many engineering education environments[8]. These include collaborative learning arrangements, team teaching and an emphasis on reflective observation, abstract conceptualization and active experimentation for experiences both in and outside of the classroom/laboratory environment[9]. Traditional laboratory work is being augmented to include evening and weekend workshops associated with students' assignments, but designed to have students consciously move from "receptor" to self-directed learners who are at ease with learning as an experiential process that actively involves them in establishing learning goals, choosing learning strategies that are most likely to help them achieve their goals, and assessing the results of their efforts[10].

Redesign efforts are expected to result in improved passing rates, students having successful mastery of the theoretical and applied learning that will be required of them in Upper Division courses, and an overall increased retention rate leading to higher graduation rates.

Active Mentoring for Female Engineering Students

Increasing the graduation rates of female engineering students is the second major focus of current efforts. The average female undergraduate engineering enrollment has been about 22% over the period 1998 to 2003. The six year graduation rate for the 1998 cohort of freshmen women is 45%. The role that mentoring and support play in the success of women in engineering and science has been internationally validated by Sir Gareth Robert's review of science and engineering skills and attitudes, completed as part of the UK Government's productivity and innovation strategy[11]. Several intervention activities are being created based on interaction between female faculty, staff and students. A team of two female engineering undergraduate students, a female staff member and a female faculty member are working on developing several activities and programs that will facilitate interactions between female engineering students[12]. Three major activities are in the development stages and include (1) The development of an all female section of the freshmen university seminar (Seminar in Critical Inquiry), (2) The development of a professional engineering seminar and (3) The initiation of the Society of Women Engineers (SWE) student chapter with formal ties to the Women in Science and Engineering (WISE) program.

In an effort to make a substantial impact on the retention rates of female engineering students, a freshmen university seminar (Seminar in Critical Inquiry) will be taught for a group of female students as one of the courses in the CircLES learning communities (cluster program) during the Fall 2005 semester. The students will be grouped together for a minimum of two courses. The cluster program at UTEP has been instrumental in increasing not only the retention rate of its students, but also the average GPA as well[1, 2]. By grouping women together, a safe and comfortable environment is created so that female engineering students feel free to discuss pertinent issues they may deem important[13]. The course will be taught by a female faculty member and the coordinator for the WISE program. Both these individuals have the combined experience of teaching students at this level and assisting women in science and engineering. The course will include topics pertaining to integration into the university, basic study skills, self-assessment, communication skills and engineering technology, with team skills integrated into every class session. After completion of the course, the students will be monitored on a semester-by-semester basis.

A Professional Engineering Seminar is being developed to assist engineering students with guidelines for maximizing employment opportunities through the following workshops: (1) Resume writing, (2) Interview Practice and (3) Pre Co-op Training. The workshops will be provided once a semester for all engineering students.

SWE is a national organization with an integrated framework that links students at university campuses to members at the national level. A SWE Chapter is being reestablished at UTEP by the two undergraduate engineering students involved in this project. As elected officers, they have collected and compiled the necessary documents required to initiate the SWE Chapter, in addition to performing the other required duties of an officer. The presence of the SWE Chapter creates a formal support structure available to all female engineering students. SWE creates the opportunity for leadership roles among female engineering students in addition to student-student interaction. At regional and national SWE conferences, students meet other female engineering students from other campuses and are given the opportunity to exchange experiences with one another. The conferences also provide students the opportunity to attend professional development workshops and to meet and interact with company representatives. As a supplement, the regional sections offer professional development modules free of cost to the student sections.

Timetable, Impact and Final Comments

The project will be undertaken in three annual cycles. The activities over the triennium are divided into a total of 48 tasks; 20 tasks have been completed in the inaugural year of the project, 17 are to be undertaken in the second year, and 11 tasks in the final year.

Each of the tasks to be completed is detailed, along with the primary participants undertaking the specified tasks. Methods to be employed are summarized therein and the tangible results to be

expected are listed, along with the interval of time during which the results are to be achieved. As results become available they are reported and posted. The time tabling includes institutionalization of the project strategies, beginning in year two of the project and intensifying in year 3 (during 2006).

The program of activities includes project organization and management strategies, monitoring points for review of progress, communications review points for monitoring of progress in analysis and publishing of results, and evaluation plans and feedback sessions. Each of these processes is repeated during each annual cycle, which ends with the seamless integration of learning methods within the programs of the College of Engineering at UTEP.

The list of tasks is flexible enough, and is in fact, planned to include modifications that occur due to unexpected results and new insights gathered during the course of each or all of the three years during which the project proceeds. The employment of the first team of Peer Master Teachers [PMTs] was completed in time to develop teaching prowess via Summer learning workshops during the first Summer of the project, and updates and new training sessions will be repeated during the second and third years of the project, compatible with some students departing and new students entering as PMTs during the course of the project. The structure of the timetable encourages close liaison in all aspects of the project between the UTEP investigators and the Department of Education Minority Science and Education Improvement Program leadership team, who are supporting the UTEP program development[14].

Summary

The core business of UTEP, as an institution, is to provide quality higher education to a student population that is diverse in terms of race/ethnicity, gender, and academic preparedness. To be effective, this also means graduating students, not just providing quality education to a few, but impacting the great majority[15]. In this context, the need to address the graduation rates through the Basic Engineering sequence is a critical need at this time. The persistence to graduation has been shown to be high once proficiency is achieved in the Basic Engineering curriculum. Therefore, completion of the BE sequence is paramount to improving graduation rates in all the student majors of the constituent programs --- Civil, Industrial, Mechanical and Metallurgical & Materials Engineering. Increasing graduation rates of minorities and women in these programs also has the potential to impact Lower Division engineering programs in the other engineering college academic components, namely, Electrical & Computer Engineering and Computer Science.

Increasing graduation rates has been chosen as the focus because it creates a "win-win" situation for everyone concerned. In successfully undertaking this project we are "making a difference," and in so doing are promoting new and appropriate paradigms for engineering education that are being recognized nationally as a model for other minority-serving institutions.

The outcomes of the project will be models that have transferability to other institutions. UTEP recognizes the need to be model of success and takes seriously the opportunity to provide exemplary success models that may be readily transferred to other minority institutions, which we hope can benefit from the experiences and gateway developments undertaken via this project.

Acknowledgement

The work reported here is funded in part through the support of the U.S. Department of Education Minority Science and Engineering Improvement Program for the project "Advancing Success of Minorities and Especially Women in Engineering at UTEP," Award No. P120A030064, and that support is gratefully acknowledged.

References

1. Kubo Della-Piana, C., Arenaz, P. Fisher, W., Flores, B., "CircLES: A Comprehensive First-Year Program for Entering Engineering and Science Students," Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Session 1237, 2001.

2. Kubo Della-Piana, C., Darnell, A., Bader, J., Romo, L., Rubio, N., Flores, B., Knaust, H. Brady, T., and Swift, A., "A Longitudinal Study of Student Persistence in Science, Technology, Engineering, and Mathematics (STEM) at a Regional Urban University," Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Session 3553, 2003.

3. Fiske, E. B. "The Undergraduate Hispanic Experience: A Case of Juggling Two Cultures," Change, 26: 29-33, 1988.

4. Rendon, L. I., Hope, R. 0., and Associates, Educating a New Majority: Transforming America's Educational System for Diversity, San Francisco: Jossey-Bass, 1996.

5. Rendon, L. I. & Nora, A., "Hispanic Students: Stopping the Leaks," Educational Record 68: 79-85, 1988.

6. Pascarella, E. T. and Terenzini, P. T., How College Affects Students: Findings and Insights from Twenty Years of Research, San Francisco: Jossey-Bass, 1991.

7. Golding, P., Azpeitia, J., Gutierrez, J. Jauregui, J, Perez, O.A. and Pitcher, M.T., "Powering a Cyber-Community with Team-Teaching and Nuke Technology," Third Annual International SUN Conference on Teaching and Learning: "Cooperative, Collaborative, and Team-Based Learning," University of Texas at El Paso, Session #50, March 5 – 6, 2004.

8. Corwin, S., and Chase, J., Peer Instruction for Student Engagement, NSF # 0229652, May 01, 2003.
Astin, A. W., "The Measured Effects of Higher Education," Annals of the American Academy of Political and Social Science, Vol. 404, pp. 1-20, 1972.

9. Bohrson, W.A., Kurtz, M.J., Piacsek, A.W., Glasby, S.P., and Gellenbeck, E.M., In Answer to a National Challenge: A Pilot Program to Increase Participation in Science, Technology, and Mathematics [STEM] Fields, NSF # 0230395, January 01, 2003.

10. Renner Martinez, J. and Knaust, H. *et al*, An Academic Model for Student Success in Urban Commuter Institutions, 21st Annual Conference on the First Year Experience, Kissimmee, Florida, February 17-19, 2002.

11. Roberts, G., Science Policy Review 2001–2004, Report to the House of Commons Science and Technology Select Committee, London, Great Britain, April 28, 2004.

12. Flores, B.C, Kubo Della Piana, C, Brady, T., Swift, A.H.P., Knaust, H., and Renner Martinez, J., Learning Communities – It's A Team Effort, Southwest Regional Learning Communities Conference, Tempe, AZ, February 28 – March 2, 2002.

13. Light, R. Making the Most of College: Students Speak Their Minds, Cambridge, MA: Harvard University Press, 2001.

14. Flores, B.C., Swift, A., Brady, T., and Renner Martinez, J., The Effectiveness of an Advisory Board as a Critical Friend, 2002 Frontiers in Education Conference, Boston. MA, November 6 – 9, 2002.

15. Boyer, E.L., College: The Undergraduate Experience In America, New York: Harper & Row, 1987.

Biographical Information

Walter W. Fisher is Phelps Dodge Professor of Metallurgical Engineering and an Associate Dean of the College of Engineering. He has been a key player in the development and implementation of an entering students program for the College of Engineering and manages the Pre-Engineering program.

Peter Golding is an Associate Professor in Metallurgical and Materials Engineering. He has been instrumental in implementing and managing the Basic Engineering program in the College of Engineering. He is Principal Investigator of the U.S. Department of Education grant supporting the work reported in this paper.

Stella A. Quinones is an Assistant Professor in Electrical and Computer Engineering. She has played a critical role in designing and implementing courses for the entering students program and has coordinated the teams that teach these courses. She is a key role model and mentor for women students in the College of Engineering.

Roberto Osegueda is a Professor in Civil Engineering and an Associate Dean of the College of Engineering and has served as Interim Dean of the College. He has been a key player in the design and implementation of the Basic Engineering program.

Barry Benedict is Dean of the College of Engineering. He has extensive experience at several universities in student retention initiatives, diversity issues and curriculum development. He is a strong advocate for this work and a mentor to the team.